Pinnacles National Monument

1998-1999 Exotic Fish Removal -- Summary Report

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December, 1999

Abstract: In summer 1998, thousands of green sunfish (*Lepomis cyanellus*) were observed in Chalone Creek at Pinnacles National Monument (PINN). These aggressive predatory exotic fish are considered a serious threat to our native stream ecosystem, particularly to our populations of federally threatened California red-legged frogs (CRLF) (*Rana aurora draytonii).* Streams were electroshocked in 1998 and 1999, and all known green sunfish within PINN were eradicated. Hundreds of exotic mosquitofish (*Gambusia affinis*) were also observed, but not targeted for removal. Mosquitofish remain a threat to our stream ecosystem. Long-term protection of our stream ecosystem from exotic fish infiltration will require identification and isolation or removal of source populations outside PINN.

The first known introduction of exotic fish in California occurred in 1871 (Moyle 1976a). Since then, at least 56 species of exotic fish have become established in California (Dill and Cordone 1997). To the detriment of native fish fauna, exotic fish now dominate most of the major waters of California (Moyle 1976b). They have been implicated as a major factor in amphibian declines throughout the state (e.g., Bradford 1989, Fellers and Drost 1993, Fisher and Shaffer 1996). Although little research has been conducted on their impact on native aquatic invertebrates and vegetation, it is expected to be significant.

At PINN, exotic fish are considered a threat to the health of our stream ecosystem in general, and to the federally threatened CRLF in particular. They may feed on frog eggs and tadpoles, and may compete with frogs for food resources. The only native fish species currently known to inhabit PINN is threespine stickleback (*Gasterosteus aculeatus*). Many exotic fish species are either known or expected to occur around PINN, and it is likely that some have inhabited PINN without being documented. The following is a brief history of known exotic fish occurrences at PINN:

Catfish (*Ictalurus* sp.)--Exotic catfish inhabited the Bear Gulch Reservoir at least as early as 1984. In 1986 the reservoir was temporarily drained to inspect the dam, and the catfish were killed by electroshocking. Any that may have escaped into the stream did not survive. Catfish are native to the eastern USA, and seven species have been introduced to California. Their tolerance for backwater areas might allow them to survive in the reservoir, but their ability to survive in our streams through the summer is questionable.

Fathead minnow (*Pimephales promelas*).--In August 1979, this species was reported as “common” in pools in Chalone Creek at the Chalone Creek Bridge. Although PINN did not remove any, fathead minnow has not been observed here since. Its ability to survive in sluggish streams makes it a likely candidate for future infestations.

Mosquitofish.--We suspect that mosquitofish have been in our streams for decades, although our earliest confirmed records are from 1993 and 1994, in Chalone Creek below its confluence with Frog Canyon Creek. In 1998 and 1999, hundreds were observed in the same area, and small numbers were seen in the extreme upper section of North Fork Chalone Creek (Fig. 1). Native to the southeastern USA, mosquitofish were introduced to California in 1922 to control mosquitoes (Moyle 1976b). They have since spread throughout most of the state, and they continue to be introduced for mosquito control. They are known to feed on amphibian eggs (Grubb 1972). At PINN they coexist with, and are usually outnumbered by, threespine sticklebacks. These factors, tempered with their small size and lack of aggressiveness, make them a moderate threat to the health of our stream ecosystem.

Green sunfish.--In June 1979, green sunfish were observed in North Fork Chalone Creek below Willow Spring. In August 1979, they were reported as "abundant" in Chalone Creek at the Chalone Creek Bridge, and were also seen in Chalone Creek above Willow Spring and within 1.5 km of its confluence with Sandy Creek. In May 1981, green sunfish were reported near the confluence of Bear Gulch Creek and Chalone Creek. In August 1993, several fish of questionable identity (probably green sunfish) were observed in lower Bear Gulch Creek. Reports of possible Sacramento Perch in Chalone Creek near the Chalone Creek Bridge in 1993 and 1994 may have been green sunfish. In 1998, thousands of green sunfish were observed in lower Bear Gulch Creek, in Chalone Creek above its confluence with Bear Gulch Creek, and in North Fork Chalone Creek (Fig. 1).

The green sunfish is native to the Mississippi drainage system, and was introduced to California in 1891 as a sport fish. It is often spread unintentionally because its young are difficult to distinguish from those of the bluegill (*Lepomis macrochirus*), a popular sport fish. Green sunfish is a particularly problematic exotic species, occurring in all major California river systems except for the Klamath (Moyle 1976b). It is an aggressive, voracious predator with a high fecundity and high tolerance for warm water, low oxygen, and high alkalinity. As a result, it tends to form large, stunted populations in pond and backwater habitats, often

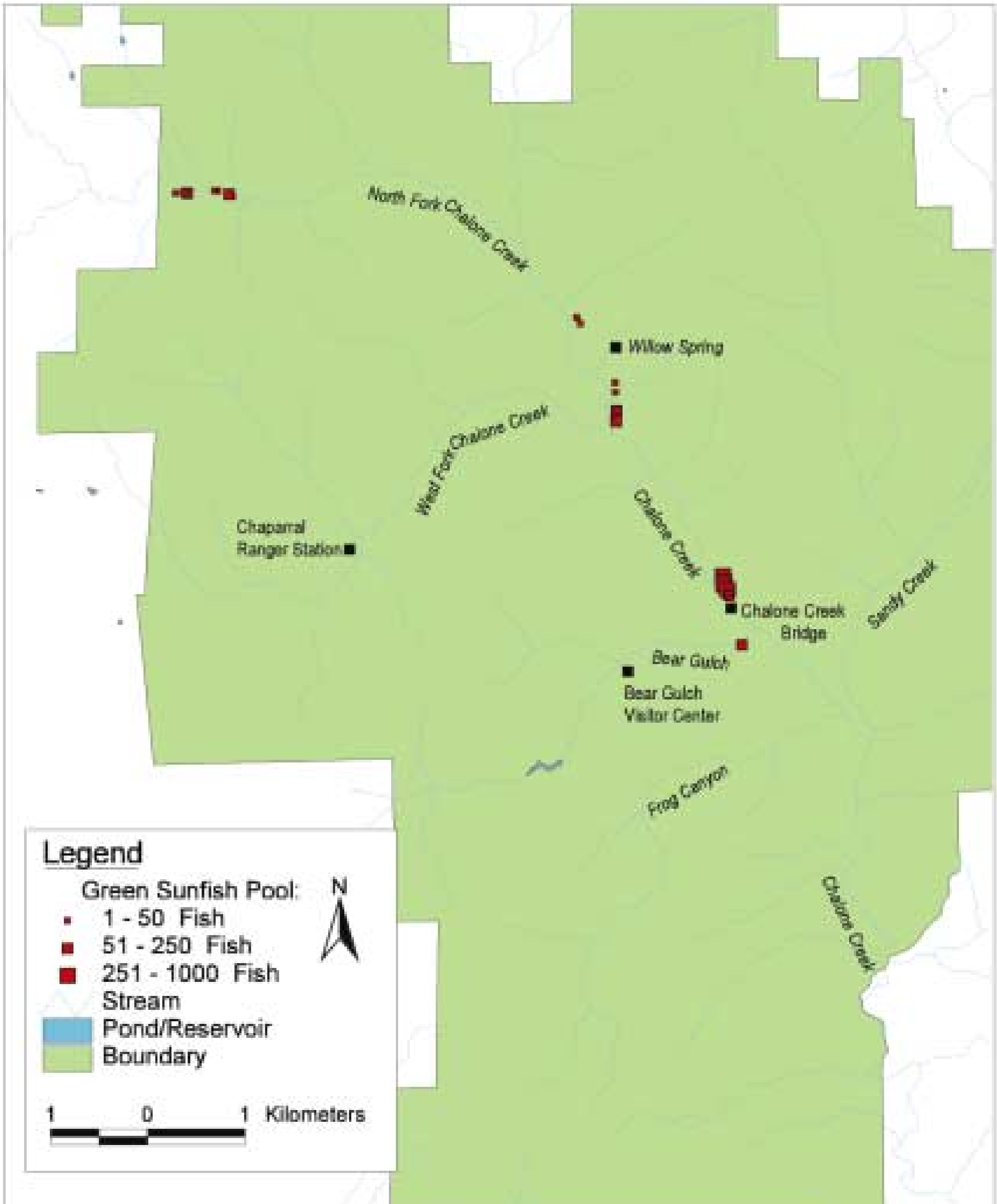

Fig. 1. 1998 distribution of green sunfish at Pinnacles National Monument.

eliminating all other fish species from such areas (McGinnis 1984). However, green sunfish often coexist with threespine sticklebacks at PINN.

Green sunfish are known to readily prey on amphibian larvae (Kats et al.1988). The decimation of amphibian populations upon introduction of green sunfish has been documented (Petranka 1983). Green sunfish at PINN inhabit stream pools, often reaching populations of many hundreds. These pools are essential summer habitat for all stages of the CRLF life cycle. Although we have no direct evidence that exotic fish harm CRLF at PINN, several pools that in 1994 supported CRLF and no green sunfish, in 1998 supported green sunfish and no CRLF. We know that our CRLF population has crashed since 1994, but we have no way to separate the effects of exotic fish from those of the floods of 1995 and 1998, or from other factors. Furthermore, it is not uncommon for healthy amphibian populations to fluctuate wildly due to natural causes (Pechmann et al. 1991, Pechmann and Wilbur 1994). However, we must err on the side of caution, so we regard green sunfish as a serious threat to CRLF and the general health of our stream ecosystem.

Sacramento perch (*Archoplites interruptus*).--In 1993, Sacramento perch were collected from North Fork Chalone Creek. We have questionable records from 1993 and 1994 in North Fork Chalone Creek near Willow Spring, and Chalone Creek near the Chalone Creek Bridge. This species is a California native, but may not be native to PINN. Although not aggressive, it is likely a threat to CRLF because it shares many other characteristics with its relative the green sunfish. In 1993, the groundwork was laid for a Sacramento Perch removal project, but it was not implemented. This species is no longer found in PINN, presumably because it did not survive the intervening summer drying periods.

Although some of our knowledge about exotic fish at PINN comes from anecdotal observations, systematic stream surveys have provided us with the best information. California Department of Fish and Game conducted surveys at six sites in August 1979 to inventory fisheries resources at PINN. The National Park Service conducted stream surveys for amphibians in 1992-1994, during which we documented the presence and distribution of Sacramento perch, mosquitofish, and possibly green sunfish. Unfortunately, we did not conduct stream surveys in 1995-1997. The lack of data from these years limits our understanding of the spread of exotic fish at PINN, and their effects on CRLF. We resumed stream surveys for amphibians in June 1998, which alerted us to the extensive infestation of green sunfish. In order to maintain the health of our stream ecosystem and protect our CRLF populations, in September 1998 we initiated an exotic fish removal program (Fesnock, 1998).

STUDY AREA

Pinnacles National Monument is located in eastern Monterey and western San Benito Counties, California, USA (36°28’25”N, 121°11’25”W). It is dominated by chaparral (78%), with blue oak (*Quercus douglasii*) woodland (9%), cis-montane introduced grassland (4%), mixed riparian (2.5%), and several other plant communities (Stitt and Husari 1983; Halvorsen and Clark 1989).

The mixed riparian plant community is characterized by western sycamore (*Platanus racemosa*), Fremont’s cottonwood (*Populus fremontii*), red willow (*Salix laevigata*), sandbar willow (*S. exigua*), arroyo willow (*S. lasiolepis*), coast live oak (*Q. agrifolia*), gray pine (*Pinus sabiniana*), California buckeye (*Aesculus californica*), California blackberry (*Rubus ursinus*), and poison oak (*Toxicodendron diversilobum*).

Elevation ranges from 244 to 982 m. Mean winter and summer temperatures are 8.2^{o}C and 22.6^{o}C, respectively. The climate is Mediterranean, with 80% of the rainfall occurring from November to April, and virtually none in the summer. Average yearly rainfall is 44 cm, ranging from 20 to 90 cm (National Oceanic and Atmospheric Administration 1999). The terrain is steep and the soils are mostly coarse and poorly developed, with some areas of bare rock and badlands. This results in a low water holding capacity from year to year, and a flashy stream response to intense rainfall (C. A. Moore, PINN, personal communication).

The Monument lies almost entirely in the Chalone Creek drainage, which consists of mostly low sinuosity sand and gravel or braided cobble channels in its lower reaches, with many of the upper reaches being bedrock controlled. It consists mostly of intermittent streams, with a few perennial sections. Typical annual peak flow for Chalone Creek below its confluence with Bear Gulch Creek is 8.5 m^3/s (300 cfs) (C. A. Moore, PINN, personal communication). In drought years the streams dry almost completely in the summer, while in wetter years several kilometers of streams may flow throughout the year.

Aquatic animals at PINN must be able to either withstand these conditions, or re-colonize once adverse conditions have passed. Native stream-dependent amphibians and reptiles at PINN include CRLF, foothill yellow-legged frog (*Rana boylii*, extirpated), Pacific chorus frog (*Pseudacris regilla*), western toad (*Bufo boreas*), western spadefoot toad (*Spea hammondii*, extirpated?), two-striped garter snake (*Thamnophis hammondii*, extirpated?), and western pond turtle (*Clemmys marmorata*). Although PINN may have once supported several native fish species including California Roach (*Hesperoleucus symmetricus*), only threespine stickleback remains. Other native fish species, such as hitch (*Lavinia exilicauda*), may enter our streams during high flow periods, leaving before the summer drying period. The Pinnacles riffle beetle (*Optioservus canus*) is a stream invertebrate endemic to PINN, recorded only from Chalone Creek.

METHODS

To determine the extent of the exotic fish infestation, in spring and summer of 1998 and 1999 we surveyed all streams with appreciable water. We flagged green sunfish sites and marked their location on a topographic map. After the initial survey, we revisited the sites and recorded their location with a GeoExplorer II Global Positioning System (GPS) (Trimble, Santa Clara, California, USA). We recorded mosquitofish locations on a map, but did not flag or GPS them unless they were in the vicinity of green sunfish pools.

Due to the potential for causing harm to the federally listed CRLF, we initiated an informal consultation with the US Fish and Wildlife Service (USFWS) (A. Orton-Palmer, USFWS, personal communication). They were reluctant to allow electroshocking in the vicinity of CRLF. However, because of the immediate threat exotic fish posed to the already greatly diminished frog population, and because few frogs were seen in the vicinity of the fish, USFWS concurred with the project, with the following stipulation: we were required to search each pool for CRLF before electroshocking, and if we found any, we did not electroshock until we detected none on at least two subsequent searches.

USFWS also permitted us to net without electroshocking in the vicinity of CRLF. This method proved unsuccessful (in Fig. 2, compare visit #1 with subsequent visits). The fish quickly hid and remained out of reach of the net. Furthermore, we were never certain that we had netted all the fish in a pool. In contrast, electroshocking pulled fish out of their hiding

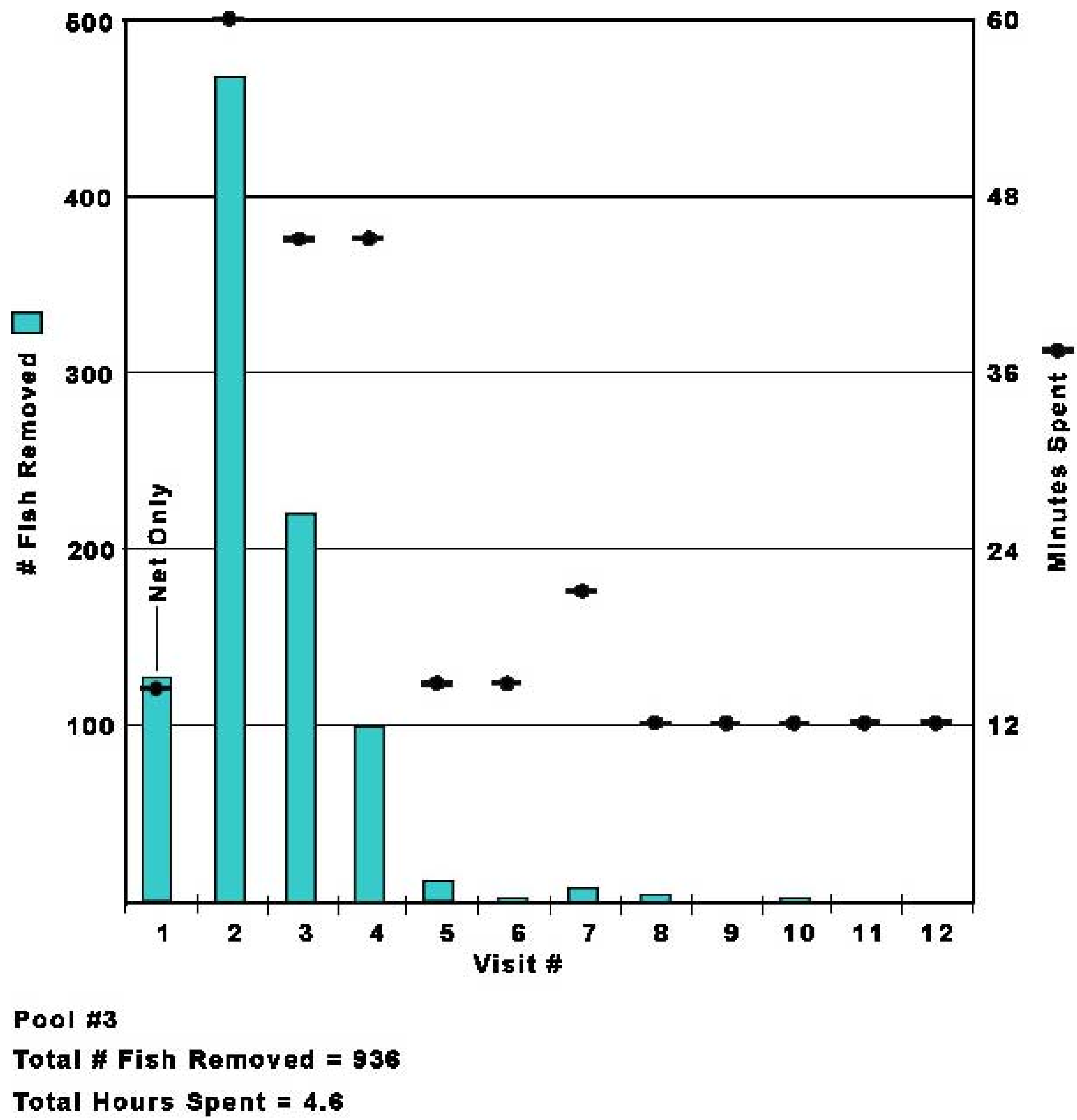

Fig. 2. Number of exotic green sunfish (*Lepomis cyanellus)* removed and time spent per visit at pool #3. This was a large and complex pool with a large green sunfish population. Note that visit #1 consisted of netting without electroshocking.

places, so if we saw none, it was likely that none were present. We therefore do not consider netting without electroshocking to be a viable option for PINN streams.

A third possible option to mitigate harm to CRLF due to electroshocking would have been to capture and hold them while electroshocking. This option was considered unacceptable for the following reasons. Pools generally require electroshocking on several visits, so frogs would need to be captured multiple times. But once captured, a frog may become more wary and harder to re-capture. Capturing and handling a frog entails the risk of spreading diseases or causing injury, and causes an increase in metabolic activity, which may last for several hours. Such disturbance would disrupt normal behavior, and could scare a frog away from prime habitat.

The action thresholds specified in the IPM Action Plan call for initiating removal efforts if we observe either a single green sunfish, or 5 pools with greater than 20 mosquitofish. Although we adhered to the action threshold for the green sunfish, we did not do so for the mosquitofish for the following reasons:

1. We were uncertain how much time and effort would be required to remove both species. We focussed first on the greatest threat, green sunfish.
2. Electroshocking is more effective on larger animals, so the level of electrical current used for green sunfish had relatively minor effects on sticklebacks and other small native animals. The higher level of electrical current necessary to stun the much smaller mosquitofish would have been much more harmful to the comparably sized native animals, and more likely deadly to the much larger CRLF.
3. The small size of mosquitofish, as well as their resemblance to native sticklebacks, makes it much more difficult to locate, identify, and remove them.

4. Because mosquitofish are so widely introduced for mosquito control purposes, their source populations may be much more difficult to control. Re-introductions may be much more likely for mosquitofish than for green sunfish.

5. Finally, mosquitofish tended to co-occur with CRLF more often than green sunfish did, making it harder to electroshock mosquitofish in the absence of frogs.

Consequently, we removed mosquitofish on a trial basis, only from the extreme upper section of North Fork Chalone Creek. These were in the vicinity of green sunfish, in small, shallow pools with poor CRLF habitat and no frog hiding places.

Fish removal activities took place during Oct-Nov 1998 and May 1999. We removed green sunfish by electroshocking with a backpack electroshocker (Smith-Root, Vancouver, Washington, USA). The shocked fish floated to the surface of the pool, usually stunned but unharmed, and were removed by net, counted, and then left to die on dry land. We moved stunned native fish and invertebrates out of the immediate area being shocked, and attempted to revive seriously stunned native fish.

We shocked a pool by walking its length and shocking all parts of the pool along the way. This tended to corral most of the fish in the far end of the pool. Once we had shocked the corralled fish, we made another pass through the pool in the opposite direction. We repeated this process until we produced few shocked fish. In most pools, the first pass stirred up silt and debris, so subsequent passes were less efficient due to reduced visibility. Also, fish that survived the first pass hid in the banks, out of range of the electroshocker.

We revisited pools once the water had cleared and surviving fish had come out of hiding, usually on a later day, and repeated the above procedure. We re-shocked most pools in this manner until we found no green sunfish. We recorded the number of fish removed and time spent shocking for each pool. Electroshocking always took place with at least two people participating: a shocker and one or more netters. For safety, at least two people present were required to be CPR-certified. Appendix A contains more details on methods used and insights gained from field experience. Sharber et al. (1994) provides a brief explanation of the biophysics of electroshocking, with implications for field methods.

We used the following equipment for this project:

- 1 backpack electroshocker
- 5 12-volt motorcycle batteries
- 2 battery chargers
- high-voltage electrical gloves (2 pairs)
- hip waders (1 pair), thigh waders (2 pairs), rubber boots
- insulated-handle dip-nets (2 large and 1 small)
- 5-gallon bucket

RESULTS

We removed a total of 3666 green sunfish from 25 pools during 31 hours of electroshocking spread over 19 field days (Fig. 3). Raw data for green sunfish are presented in Appendix B. We also removed 119 mosquitofish. Total time spent at each pool ranged from 3 minutes to over 6 hours (mean = 1.25 hours). Total number of green sunfish removed per pool ranged from 1 to 941 (mean = 147 fish). The number of visits to a pool required to remove all green sunfish ranged from 1 to 12 (mean = 4 visits) (e.g., Fig. 2), and was dependent on the number of fish present and the size and complexity of the pool.

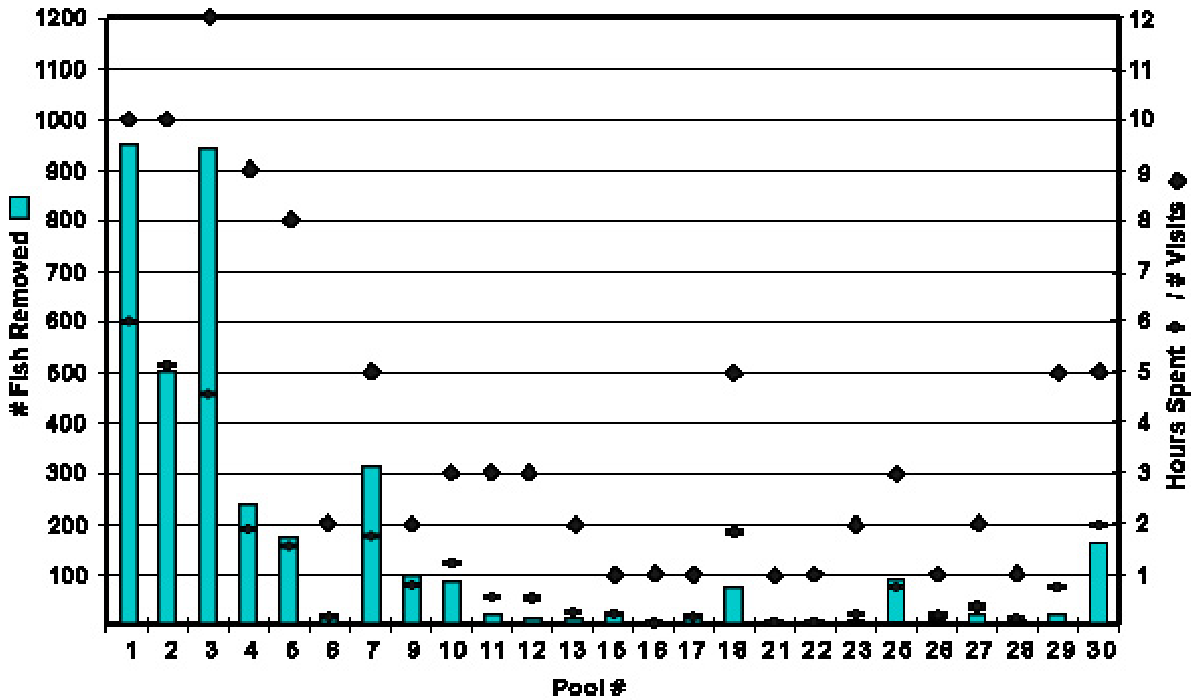

Fig. 3. Number of exotic green sunfish (*Lepomis cyanellus*) removed and number of visits per pool.

In October and November 1998, we removed all known green sunfish in PINN, except for a population in a pool continuously inhabited by a CRLF. We removed this last population in May 1999, when the frog was no longer present. Although this population was in the stream when it became continuous in winter and spring 1999, it spread no farther than to one immediately adjacent pool. Multiple stream surveys in summer 1999 revealed no green sunfish within PINN.

DISCUSSION / MANAGEMENT IMPLICATIONS

The short-term goal of this project, to remove all green sunfish from PINN, was achieved with a minimum amount of time and expense, and at little apparent cost to the resource. We observed fewer than 10 sticklebacks killed during this project, and we did not observe harm to any other native animals. This pales in comparison to the impact the green sunfish likely had on the native aquatic fauna through predation and competition. Perhaps the greatest negative impact of this project on the resource was from repeated disturbance of silt and debris in pools. The effect of this unavoidable disturbance is unknown.

Our long-term goal for controlling exotic fish in PINN is to prevent re-colonization from external source populations. To accomplish this, we must first identify those sources. This is no simple task. Green sunfish are capable of migrating upstream great distances during winter and spring when creeks are flowing. Possible sources of such migrations include Chalone Creek downstream from PINN, and the Salinas River, of which Chalone Creek is a tributary.

Green sunfish may also have invaded from portions of tributaries of Chalone Creek upstream of our boundary. Most of these dry up completely every summer, but perennial water does exist in Sandy Creek and in stock ponds associated with several creeks. The outflow from a stock pond may artificially create perennial stream conditions for a distance downstream from the pond, even though the creek may run dry before crossing our boundary. Such conditions would be undetectable from within PINN.

The fact that all populations of green sunfish in 1998 were confined to the portion of the watershed above the confluence of Chalone Creek and Sandy Creek suggests that their invasion may have originated from tributaries above Sandy Creek. Indeed, during the flood of February 1998, high water overflowed the dam of at least one stock pond outside the northwest corner of PINN (Frank Lamacchia, personal communication), providing any fish in this pond access to our waters.

The 1998 green sunfish distribution may be at least partly the result of another factor. Summer creek levels remained relatively high from 1994 to 1998, which may have allowed green sunfish to persist in several pools within PINN. If these pools were in the upper section of Chalone Creek, this could account for their 1998 distribution.

The ideal action to achieve our long-term goal would be to eliminate all exotic fish from the Chalone Creek hydrographic basin, upstream of the southern boundary of PINN. We would then need to evaluate the necessity and feasibility of options, such as fish dams, for isolating downstream populations from PINN. If elimination of upstream populations is not possible, the next best action would be to identify all external source populations. We could then evaluate options for isolating those populations from PINN.

These proactive actions would require our neighboring landowners to allow us to survey on their property. Green sunfish are generally undesirable in stock ponds because they tend to form large, stunted populations and crowd out other more desirable sport fish species (Moyle 1976b). We were therefore hopeful that our neighboring landowners would want to be rid of them as much as we do. Unfortunately, this does not appear to be the case. In early 1999, we wrote to Fred Rohnert, owner of the aforementioned stock pond northwest of PINN. We requested permission to enter his land to determine the nature of the green sunfish infestation there. He did not respond, nor did he respond to several phone messages. No other efforts have been made to investigate the location or extent of external green sunfish source populations.

If we are unable to gain the cooperation of our neighboring landowners, we should resort to the reactive option of conducting exotic fish surveys within PINN each year, or at least each post-flood year, to determine if exotics have re-infiltrated. We could then remove exotic fish as soon as is practical. We might also be able to pinpoint the source(s) of our invasions and focus future efforts there.

This reactive option should be regarded as a last resort. It allows us to maintain our "good neighbor" policy, which in the long run may help us create a protective buffer zone around PINN. But until we can gain the cooperation of our neighbors to remove source populations from their land, CRLF may be subjected to the following cycle:

1. Flooding impacts frogs through direct mortality and habitat destruction. High water levels allow exotic fish to invade new locations.
2. Exotic fish competition/predation reduces frog populations, and/or electroshocking impacts frogs. This impedes population recovery from flood impacts.
3. Drought increases frog mortality and reduces reproductive success. This further slows population recovery from flood, exotic fish, and/or electroshocking impacts.
4. Flooding re-initiates the cycle, this time with an already reduced frog population.

Of course, the situation is much more complex than that. For example, CRLF has the advantage of being able to travel over land to search for fish-free pools. It can also withstand complete drying of streams in summer, which kills fish. And we know that although green sunfish have existed in PINN at least since 1979, in 1992-1994 our red-legged population was doing quite well (Ely 1994). Nevertheless, if left untreated, it may only be a matter of time before the combined effects of exotic fish and stochastic events push our CRLF population beyond recovery.

Part of the reason for the success of the 1998-1999 exotic fish removal program is that there were so few CRLF that it was easy to electroshock without harming any. If the frog population rebounds now that the exotic fish are gone, and then the fish re-infiltrate, we may find frogs in every pool that has exotic fish. We will then be faced with the decision of whether to risk electroshocking or otherwise harming frogs to remove the fish, or wait until the frog population decreases enough to safely electroshock. This would be an unfortunate position for a resource manager to be in, as it is a no win situation for the CRLF. It is questionable whether the USFWS would allow us to electroshock in that situation, so we might be forced to do nothing but watch and wait, and hope. Unless we can gain the cooperation of our neighboring landowners, that may be all that we can do.

ACKNOWLEDGEMENTS

Thanks to S. H. DeBenedetti for laying the groundwork for this project. H. W. Werner at Sequoia National Park loaned us the electroshocker. J. J. Smith at San Jose State University provided information on green sunfish and CRLF. Alan Launer at the Stanford University Center for Conservation Biology offered technical electroshocking suggestions. F. Lamacchia provided information on historical exotic fish distributions around PINN. The following people assisted with field work: S. C. Buranek, C. Fletcher, M. Imberski, S. B. Kranz, G. L. Landry, E. L. Martin, I. I. Martin, A. L. Fesnock, C. A. Moore, L. Ruiz, L. J. Whalon, and E. A. Williams.

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Appendix A. Additional details of methods used and insights gained during the 1998-1999 Pinnacles National Monument Exotic Fish Removal Project.

- There are probably 5-10 times more fish in a pool than you think.
- Green sunfish can survive for several hours on dry land, so put them far enough from water that they can't flop back in. Also, consider that dead fish may attract raccoons and other predators of CRLF, so the farther away from the stream they are, the better.
- A battery lasts for 1-2 hours, and takes about 8 hours to charge. With 1 charger and 2 batteries, you can shock 2-4 hours a day, every day. With 1 charger and 4 batteries, you can shock 4-8 hours a day, every *other* day. With 2 chargers and 4 batteries, you can shock 4-8 hours a day, every day, if you are diligent about charging. With 2 chargers and 6 batteries, you can easily shock 4-8 hours a day, every day, because you can charge 2 while using the other 4, and you only need to charge 2 each night.
- A combination of nets and a bucket are useful. The helper usually has in one hand a net for removing stunned fish from the pool, and in the other hand something to put the fish into. Often these are a small, short-handled net and a large, long-handled net. The small net is useful for getting stunned fish out of holes and root tangles. The large net can be used to put fish in, and to scoop fish from the surface. A bucket can be kept on the shore nearby to stop and empty fish from the big net. Sometimes it is better to scoop with a large net, and dump the fish into a bucket held in the other hand.
- The electroshocker has two probes: a net and a hoop. The net is the anode and the hoop is the cathode. The anode causes fish to "swim" toward it until they become stunned. The cathode has an unpredictable effect on fish. For both probes, the intensity of effect falls off with the distance from the probe.
- If you work in one place for a while, periodically look around the cathode for the occasional stunned fish.
- Shocked fish don't always behave ideally. They will sometimes "swim" away from the probe, downward, or in loops. When stunned, they often do not float to the surface. But one fairly consistent behavior is that they turn belly up. With a good search image for their white bellies, you can see them in deep, shady, or murky water.
- The electroshocker rarely kills fish. Stunned fish sometimes recover as soon as shocking stops. To prevent escapes, keep the shocker on and the probe in the water as much as possible until all stunned fish have been removed from the immediate area.
- Set the electroshocker current and pulse rate depending on conditions and size of target animal. The higher the current, the greater the range and effect on a given animal. The smaller the animal, the higher the current necessary to affect it. The larger the volume of water around the probe, the higher the current needed to have the same effect on a given animal. The lower the pulse rate, the longer the animal "swims" before it becomes stunned. In murky water, high current will cause the unit to overload.
- To draw fish out of a hole, use a low pulse rate so that they will swim out toward you before they get stunned. Use just enough current to get your desired range and effect.
- To shock fish under a bank, place the cathode behind you as you face the bank. Start shocking with the anode out of range of the bank, and slowly move closer.

- If you have a lot of fish in an open area, you might be tempted to use a high pulse rate and high current to shock them all at once so that none escape.   But if you do that, they will all swim at once, and many will swim past the probe and keep on going. So in this case it is often better to use a low to medium pulse rate and a current strong enough that your range reaches the banks on either side of you. Then approach the group of fish slowly, pulling just a few out at a time. By staying far enough back that you leave a "comfort zone" for the fish, most of them will stay where they are. If a fish does try to swim past you, you are far enough back that you can keep the probe in its path. If the fish continues swimming forward, it will swim closer to the probe and be stunned. If it turns back toward the group, you have prevented it from getting past you, and you can get it later.
- If there are any hiding places, especially way back in banks or among roots, fish will inevitably end up stunned in there. You cannot see them, nor can you search blindly with a net, because a net won't fit in there. You will never rid a pool of fish unless you can get at them. Here's the trick. (It mucks up the water, so don't use it until you don't need to see any more, or you've already mucked up the water anyway.) Move the probe in a circular motion, up and toward you, then down and away from you. Make the upward movement strong and fast. Keep doing this consistently, and you will create a current that circulates back into the hiding place, and then up and out. The stunned fish will come floating out, right up to the surface of the water on the current you've created. When they stop coming out, modify the strength, direction, and location of your current to find more.
- As you walk a pool, keep the anode in front of you, and drag the cathode behind you as you go. Move the probe from side to side across the entire width of the pool, to prevent fish from getting behind you. Have your helper(s) walk beside you, staying about one step behind, so that they don't stir up silt and debris ahead of you.
- Fish will inevitably sneak past you, so when you get to one end of the pool, work your way back to the other end. If the water is too mucked up to see shocked fish, bring them to the surface by creating an upward current with the probe.
- As you move through a pool, you will shock some fish, but many will keep swimming ahead of you. These will end up corralled in front of you at the end of the pool. Before starting to shock a pool, think about where it would be best to corral them.
- Don't scare fish into the inlet or outlet of a pool, or else you may end up with escapees into another pool. Don't scare fish into a riffle. They hide well under the rocks, and when shocked, their wriggling is hidden by the motion of the flowing water.
- In general, it is best to work a pool in the upstream direction, so that any flow will carry the silt and debris you stir up behind you rather than ahead of you. However, other factors may outweigh this. If a pool is deep or complex at one end and shallow or lacking fish hiding places at the other end, it is best to corral the fish into the latter end.
- Green sunfish are pretty predictable as far as where they will hide in a pool. Use this to your benefit. Approach good hiding places slowly, keeping the anode far enough back that you are only pulling out as many fish as you can handle at one time. Corral fish toward the end of the pool with the hiding place that's easiest for you to work.

Appendix B. Raw data, Pinnacles National Monument Exotic Fish Removal Program, 1998-1999.

POOL #	VISIT	# REMOVED	HOURS SPENT	NET ONLY?	YEAR	MONTH	DAY
1	1	458	2.00		1998	10	21
1	2	213	1.25		1998	10	22
1	3	197	1.00		1998	10	29
1	4	41	0.75		1998	10	30
1	5	17	0.25		1998	11	6
1	6	7	0.20		1998	11	19
1	7	4	0.25		1998	11	20
1	8	2	0.20		1998	11	20
1	9	2	0.20		1998	11	20
1	10	0	0.10		1998	11	20
1 Total		**941**	**6.20**				
2	1	234	1.50		1998	10	21
2	2	52	1.00		1998	10	22
2	3	180	1.00		1998	11	3
2	4	18	0.25		1998	11	6
2	5	6	0.35		1998	11	19
2	6	2	0.20		1998	11	19
2	7	0	0.20		1998	11	19
2	8	1	0.20		1998	11	20
2	9	2	0.20		1998	11	20
2	10	0	0.20		1998	11	20
2 Total		**495**	**5.10**				
3	1	126	0.25	y	1998	10	22
3	2	467	1.00		1998	10	22
3	3	219	0.75		1998	10	23
3	4	99	0.75		1998	10	27
3	5	12	0.25		1998	10	30
3	6	1	0.25		1998	11	6
3	7	7	0.35		1998	11	19
3	8	4	0.20		1998	11	19
3	9	0	0.20		1998	11	19
3	10	1	0.20		1998	11	20
3	11	0	0.20		1998	11	20
3	12	0	0.20		1998	11	20
3 Total		**936**	**4.60**				

Appendix B (Cont.) Raw data, Pinnacles National Monument Exotic Fish Removal Program, 1998-1999.

POOL #	VISIT	# REMOVED	HOURS SPENT	NET ONLY?	YEAR	MONTH	DAY
4	1	120	0.50		1998	10	23
4	2	75	0.35		1998	10	27
4	3	6	0.20	y	1998	11	3
4	4	20	0.20		1998	11	19
4	5	9	0.25		1998	11	19
4	6	0	0.10		1998	11	19
4	7	1	0.10		1998	11	20
4	8	0	0.10		1998	11	20
4	9	1	0.10		1998	11	20
4 Total		**232**	**1.90**				
5	1	104	0.50		1998	10	22
5	2	7	0.15		1998	10	27
5	3	40	0.30		1998	10	27
5	4	10	0.20		1998	11	19
5	5	4	0.20		1998	11	19
5	6	0	0.10		1998	11	19
5	7	1	0.10		1998	11	20
5	8	0	0.10		1998	11	20
5 Total		**166**	**1.65**				
6	1	5	0.05		1998	10	27
6	2	1	0.05		1998	11	19
6 Total		**6**	**0.10**				
7	1	253	0.75		1998	11	3
7	2	45	0.40		1998	11	6
7	3	4	0.25		1998	11	19
7	4	6	0.25		1998	11	20
7	5	0	0.10		1998	11	20
7 Total		**308**	**1.75**				
9	1	91	0.70		1998	11	4
9	2	0	0.15		1998	11	6
9 Total		**91**	**0.85**				
10	1	43	0.50		1998	11	4
10	2	13	0.30		1998	11	6
10	3	22	0.40		1998	11	20
10 Total		**78**	**1.20**				
11	1	6	0.10		1998	11	4
11	2	10	0.20		1998	11	6
11	3	1	0.20		1998	11	20
11 Total		**17**	**0.50**				

Appendix B (Cont.) Raw data, Pinnacles National Monument Exotic Fish Removal Program, 1998-1999.

POOL #	VISIT	# REMOVED	HOURS SPENT	NET ONLY?	YEAR	MONTH	DAY
12	1	6	0.25		1998	11	4
12	2	3	0.10		1998	11	4
12	3	0	0.10		1998	11	6
12 Total		**9**	**0.45**				
13	1	6	0.10		1998	11	4
13	2	0	0.10		1998	11	6
13 Total		**6**	**0.20**				
15	1	21	0.20		1998	11	5
15 Total		**21**	**0.20**				
16	1	1	0.05		1998	11	5
16 Total		**1**	**0.05**				
17	1	14	0.10		1998	11	9
17 Total		**14**	**0.10**				
18	1	18	0.40		1998	11	9
18	2	32	0.75		1998	11	12
18	3	14	0.25		1998	11	12
18	4	3	0.25		1998	11	16
18	5	0	0.20		1998	11	16
18 Total		**67**	**1.85**				
21	1	1	0.05		1998	11	9
21 Total		**1**	**0.05**				
22	1	1	0.05		1998	11	9
22 Total		**1**	**0.05**				
23	1	4	0.05		1998	11	9
23	2	0	0.10		1998	11	12
23 Total		**4**	**0.15**				
25	1	68	0.25		1998	11	9
25	2	14	0.25		1998	11	12
25	3	0	0.20		1998	11	16
25 Total		**82**	**0.70**				
26	1	1	0.10		1998	11	12
26 Total		**1**	**0.10**				

Appendix B (Cont.) Raw data, Pinnacles National Monument Exotic Fish Removal Program, 1998-1999.

POOL #	VISIT	# REMOVED	HOURS SPENT	NET ONLY?	YEAR	MONTH	DAY
27	1	14	0.25		1998	11	12
27	2	2	0.10		1998	11	12
27 Total		**16**	**0.35**				
28	1	1	0.10		1998	11	12
28 Total		**1**	**0.10**				
29	1	1	0.10		1998	11	20
29	2	6	0.20	y	1999	5	4
29	3	2	0.10	y	1999	5	13
29	4	5	0.20		1999	5	14
29	5	0	0.10		1999	5	17
29 Total		**14**	**0.70**				
30	1	121	0.75		1998	11	20
30	2	10	0.30	y	1999	5	4
30	3	9	0.30	y	1999	5	13
30	4	16	0.30		1999	5	14
30	5	2	0.30		1999	5	17
30 Total		**158**	**1.95**				
Grand Total		**3666**	**30.85**				